



Grand Challenge Architecture and its Interface to STAR

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**presenting for the Grand Challenge collaboration
(<http://www-rnc.lbl.gov/GC/>)**

**March 27, 2000
STAR MDC3 Analysis Workshop**



Outline

- **GCA Overview**
- **STAR Interface:**
 - *fileCatalog*
 - *tagDB*
 - *StGCAClient*
- **Current Status**
- **Conclusion**



GCA: Grand Challenge Architecture

- *An order-optimized prefetch architecture for data retrieval from multilevel storage in a multiuser environment*
- Queries select events and specific event components based upon tag attribute ranges
 - query estimates are provided prior to execution
 - collections as queries are also supported
- Because event components are distributed over several files, processing an event requires delivery of a “bundle” of files
- Events are delivered in an order that takes advantage of what is already on disk, and multiuser policy-based prefetching of further data from tertiary storage
- GCA intercomponent communication is CORBA-based, but physicists are shielded from this layer



Participants

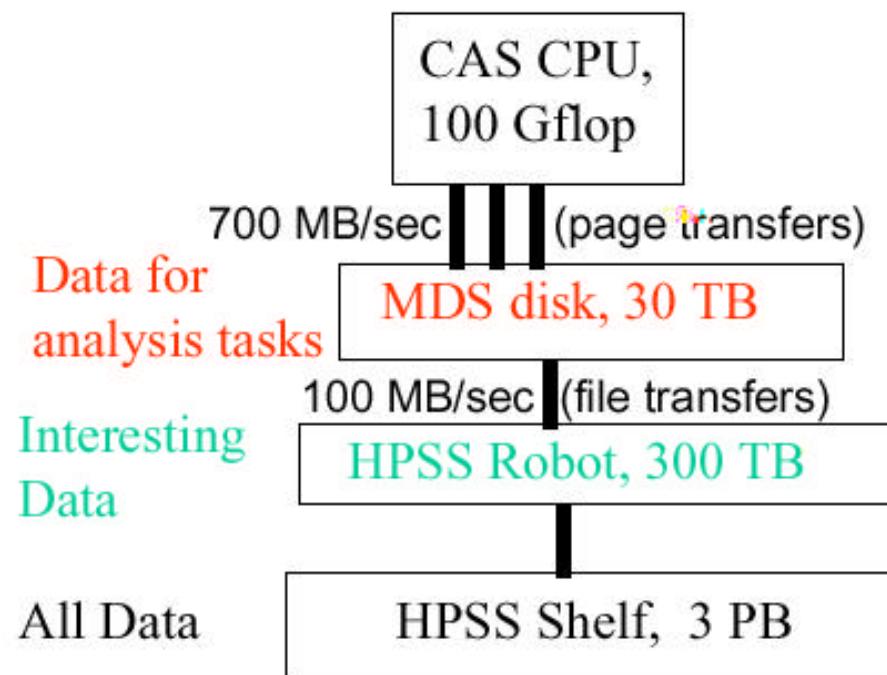
- **NERSC/Berkeley Lab**
 - L. Bernardo, A. Mueller, H. Nordberg, A. Shoshani, A. Sim, J. Wu
- **Argonne**
 - D. Malon, E. May, G. Pandola
- **Brookhaven Lab**
 - B. Gibbard, S. Johnson, J. Porter, T. Wenaus
- **Nuclear Science/Berkeley Lab**
 - D. Olson, A. Vaniachine, J. Yang, D. Zimmerman



Problem

- There are several
 - Not all data fits on disk (\$\$)
 - Part of 1 year's DST's fit on disk
 - What about last year, 2 year's ago?
 - What about hits, raw?
 - Available disk bandwidth means data read into memory must be efficiently used (\$\$)
 - don't read unused portions of the event
 - Don't read events you don't need
 - Available tape bandwidth means files read from tape must be shared by many users, files should not contain unused bytes (\$\$\$\$)
 - Facility resources are sufficient only if used efficiently
 - Should operate steady-state (nearly) fully loaded

Bottlenecks



Data for analysis tasks

Interesting Data

All Data

Bulk bandwidth numbers meet estimated requirements assuming 100% efficiency.

How to achieve bulk bandwidth?

What fraction of data transferred is useful to programs?!!!

Keep recently accessed data on disk, but manage it so unused data does not waste space.

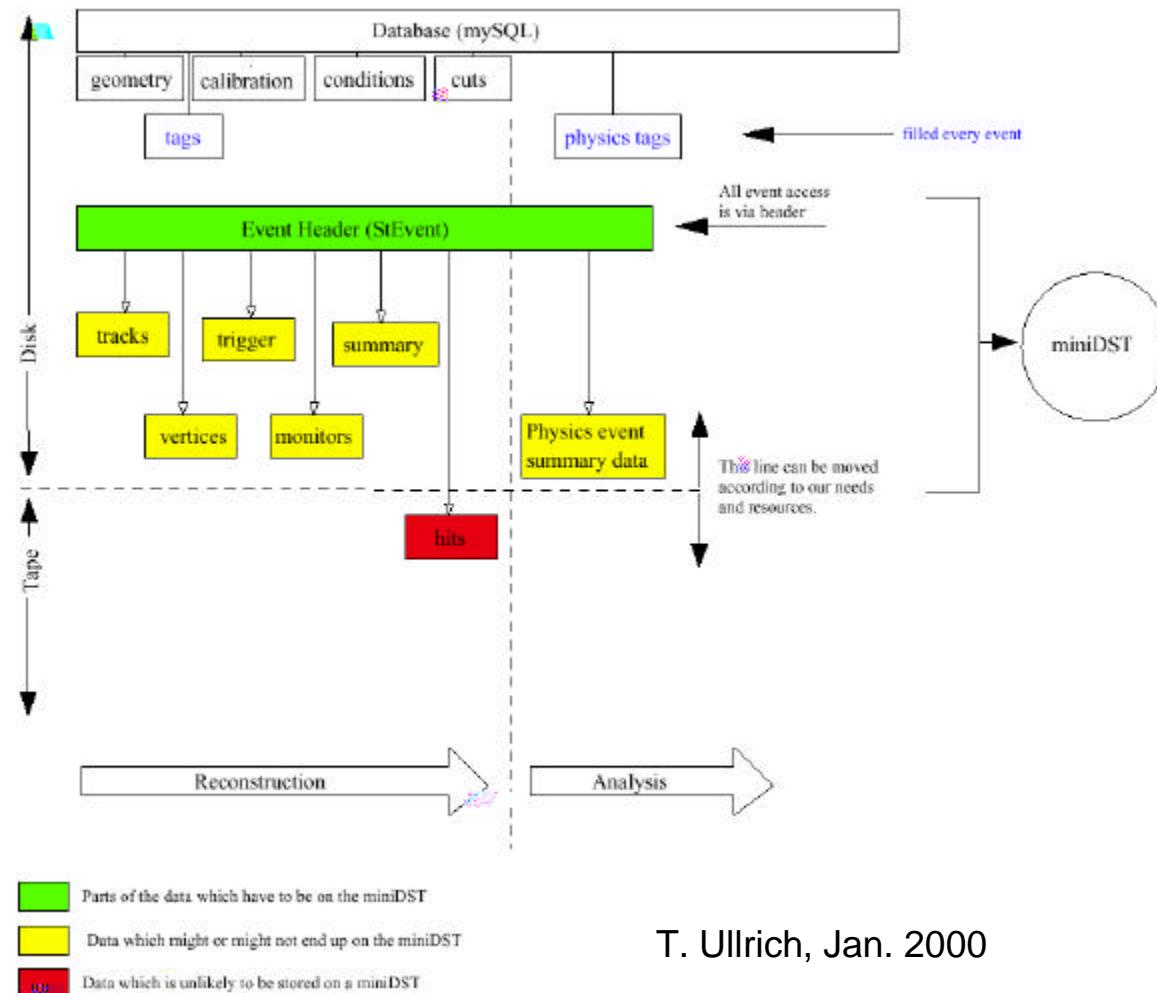
Try to arrange that 90% of file access is to disk and only 10% are retrieved from tape.



Solution Components

- **Split event into components across different files so that most bytes read are used**
 - Raw, tracks, hits, tags, summary, trigger, ...
- **Optimize file size so tape bandwidth is not wasted**
 - 1GB files, → means different # of events in each file
- **Coordinate file usage so tape access is shared**
 - Users select all files at once
 - System optimizes retrieval and order of processing
- **Use disk space & bandwidth efficiently**
 - Operate disk as cache in front of tape

STAR Event Model



T. Ullrich, Jan. 2000



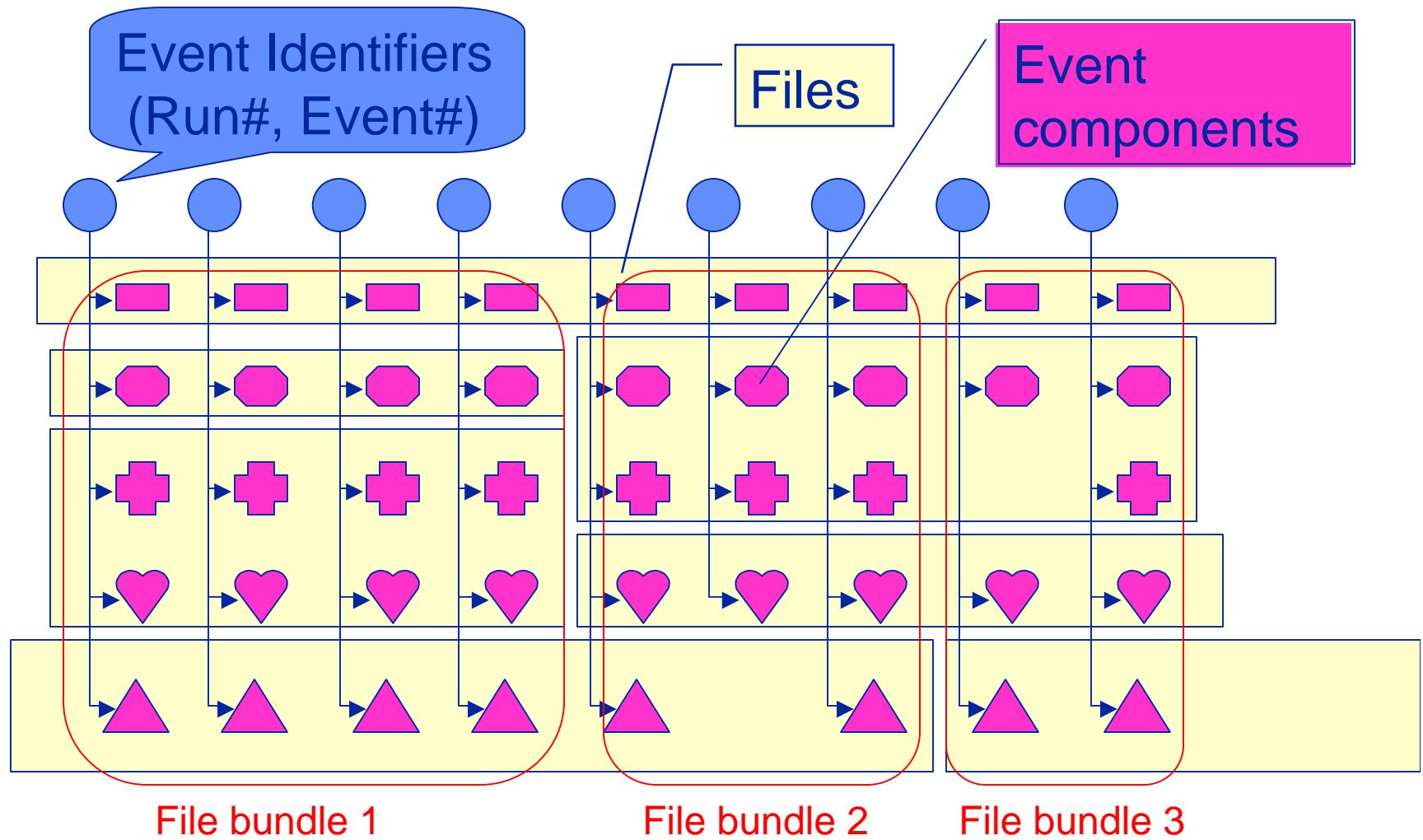
Analysis of Events

- **1M events = 100GB – 1TB**
 - 100 – 1000 files (or more if not optimized)
- Need to coordinate event associations across files
- Probably have filtered some % of events
 - Suppose 25% failed cuts after trigger selection
 - Increase speed by not reading these 25%
- Run several batch jobs for same analysis in parallel to increase throughput
- Start processing with files already on disk without waiting for staging from HPSS

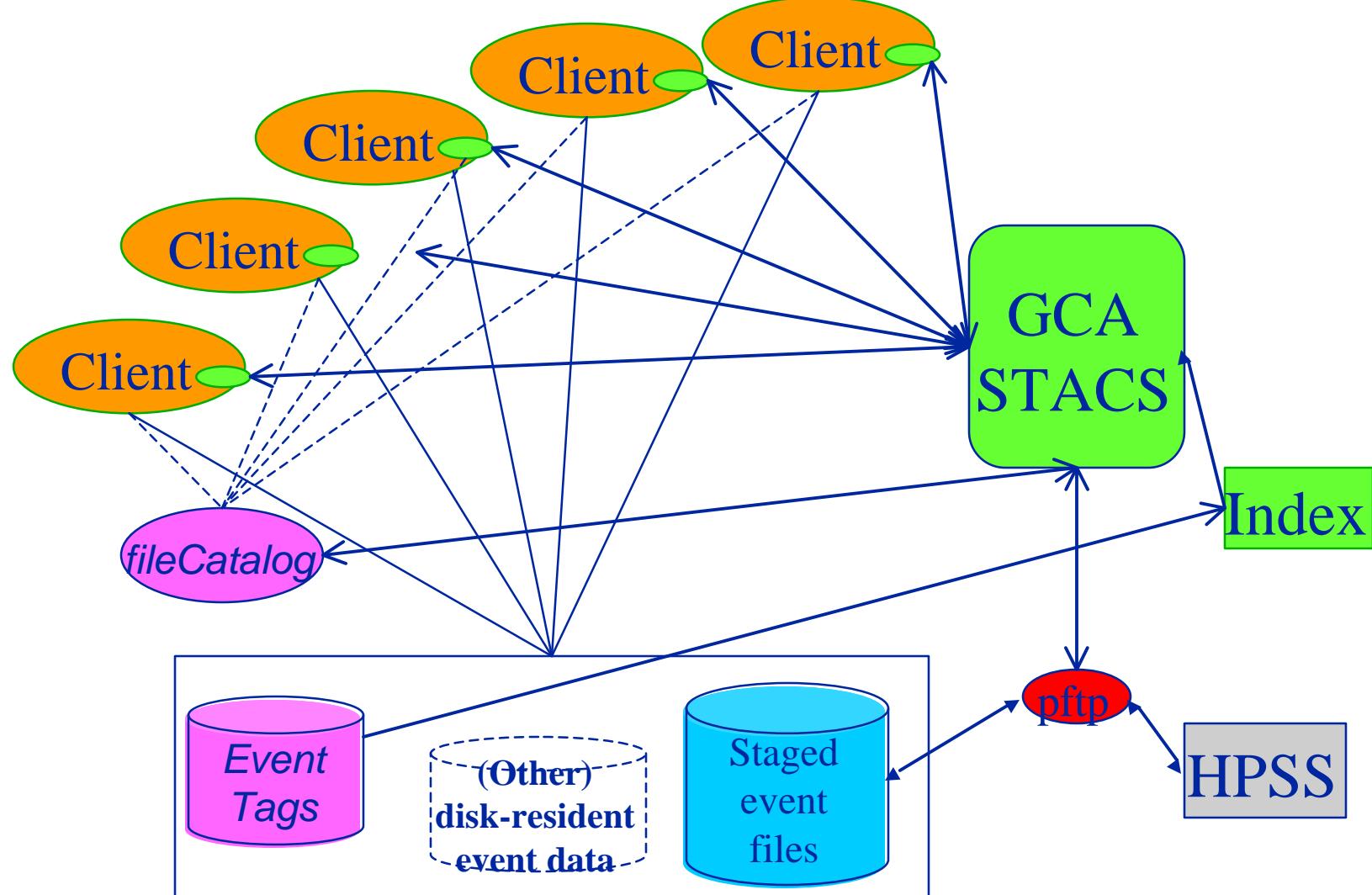
In the Details

- Range-query language, or query by event list
 - “NL_a>700 && run=101007”,
 - {e1,r101007;e3,r101007;e7;r101007 ...}
 - Select components: dst, geant, ...
- Query estimation
 - # events, # files, # files on disk, how long, ...
 - Avoid executing incorrect queries
- Order optimization
 - Order of events you get maximizes file sharing and minimizes reads from HPSS
- Policies
 - # of pre-fetch, # queries/user, # active pftp connections, ...
 - Tune behavior & performance
- Parallel processing
 - Submitting same query token in several jobs will cause each job to process part of that query

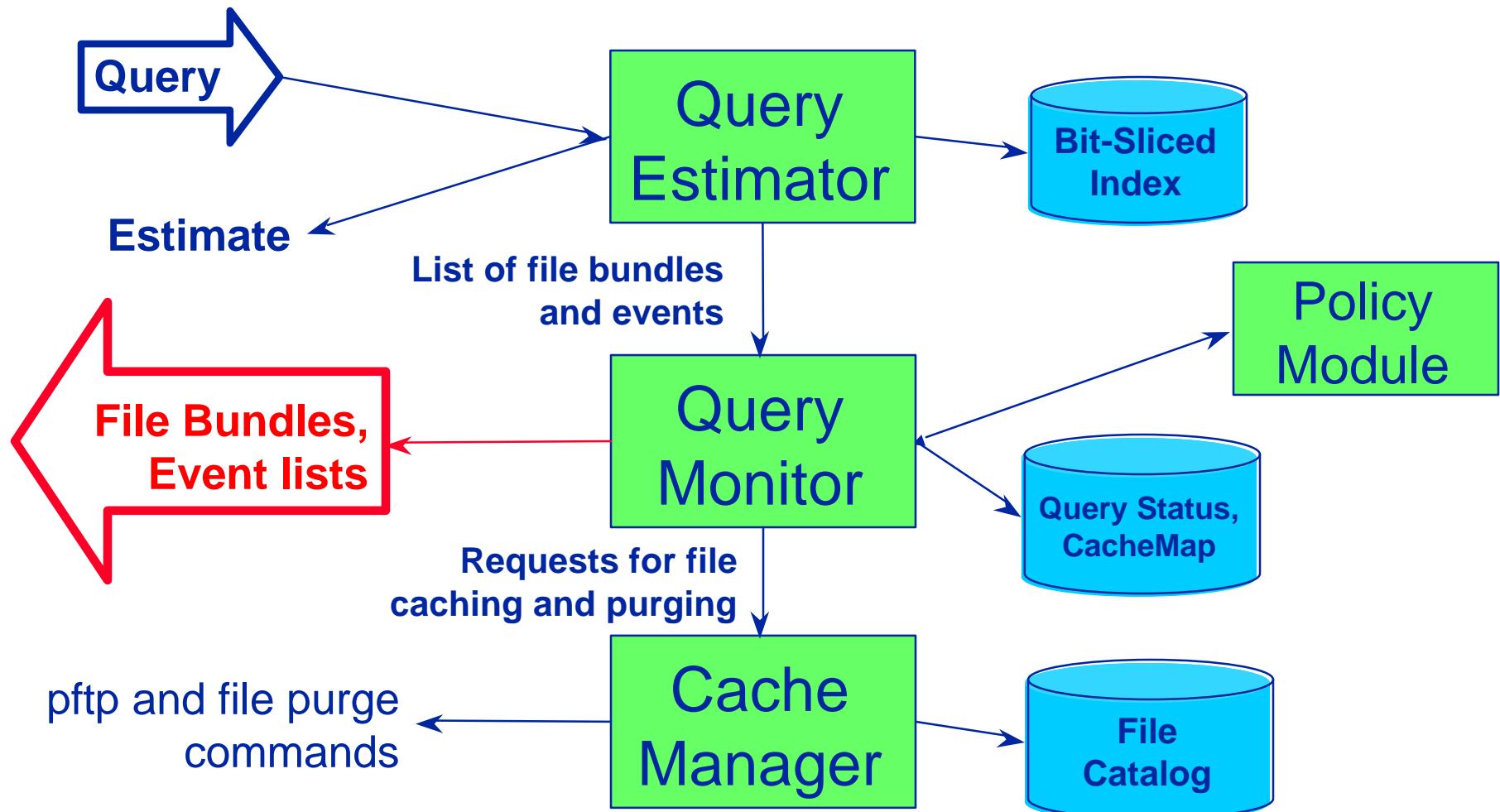
Organization of Events in Files



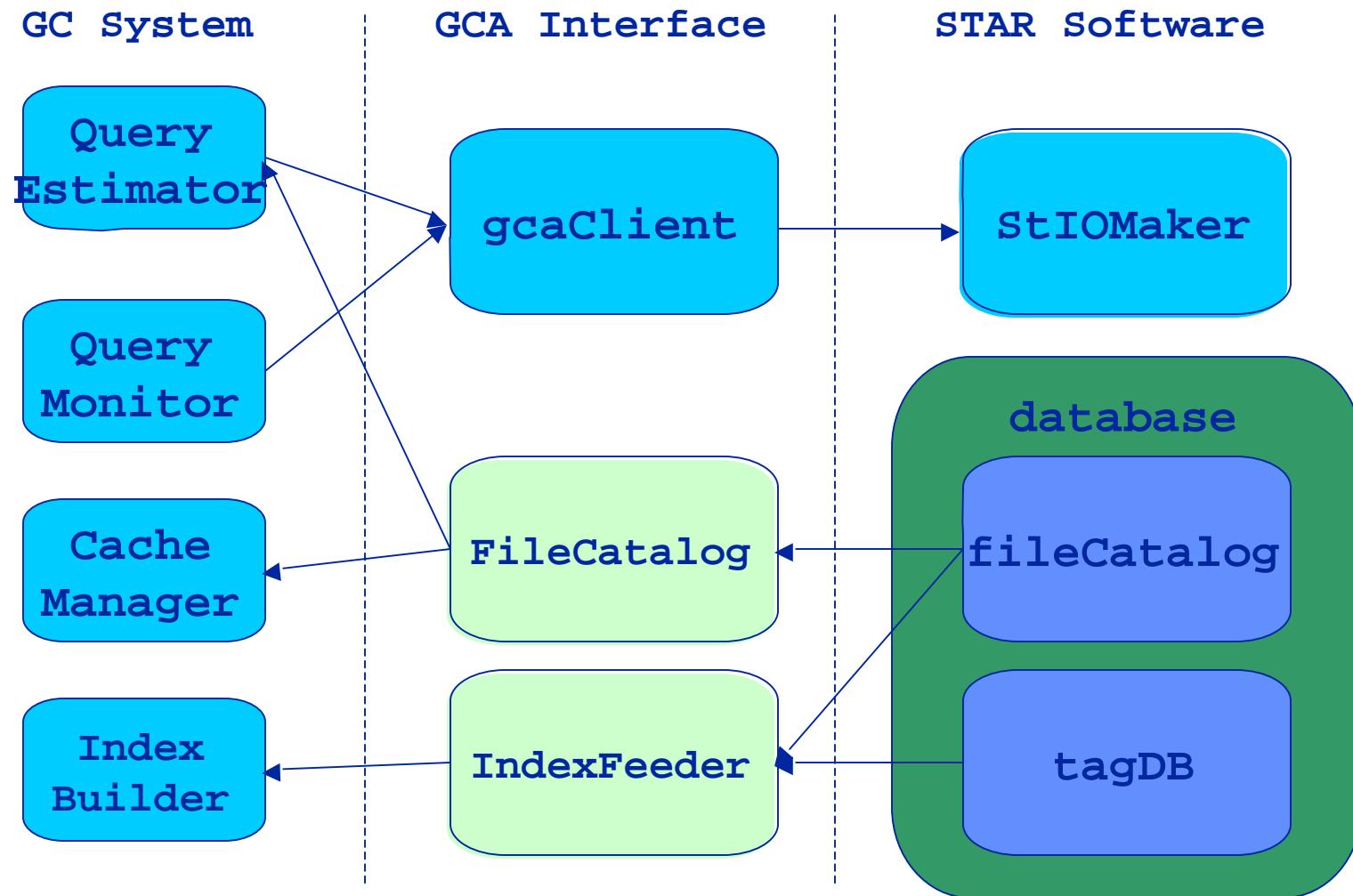
GCA System Overview



STACS: STorage Access Coordination System



Interfacing GCA to STAR





Limiting Dependencies

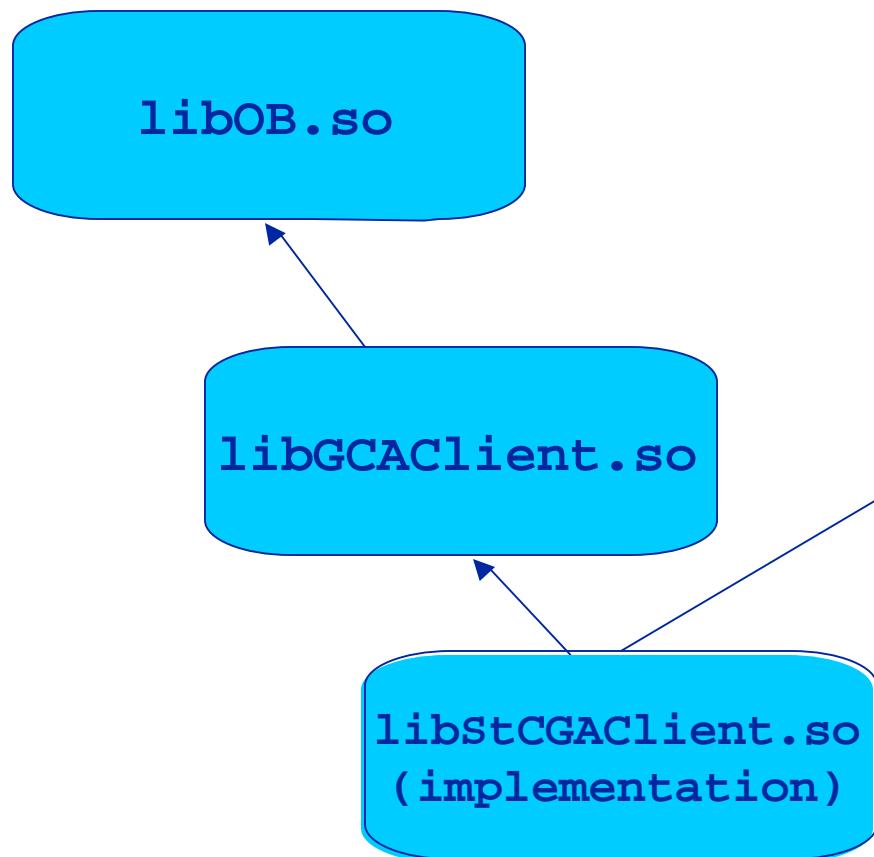
STAR-specific & GCA-dependent

- **IndexFeeder server**
 - IndexFeeder read the “tag database” so that GCA “index builder” can create index
- **FileCatalog server**
 - FileCatalog queries the “file catalog” database of the experiment to translate fileID to HPSS & disk path
- **gcaClient interface**
 - Experiment sends queries and get back filenames through the gcaClient library calls

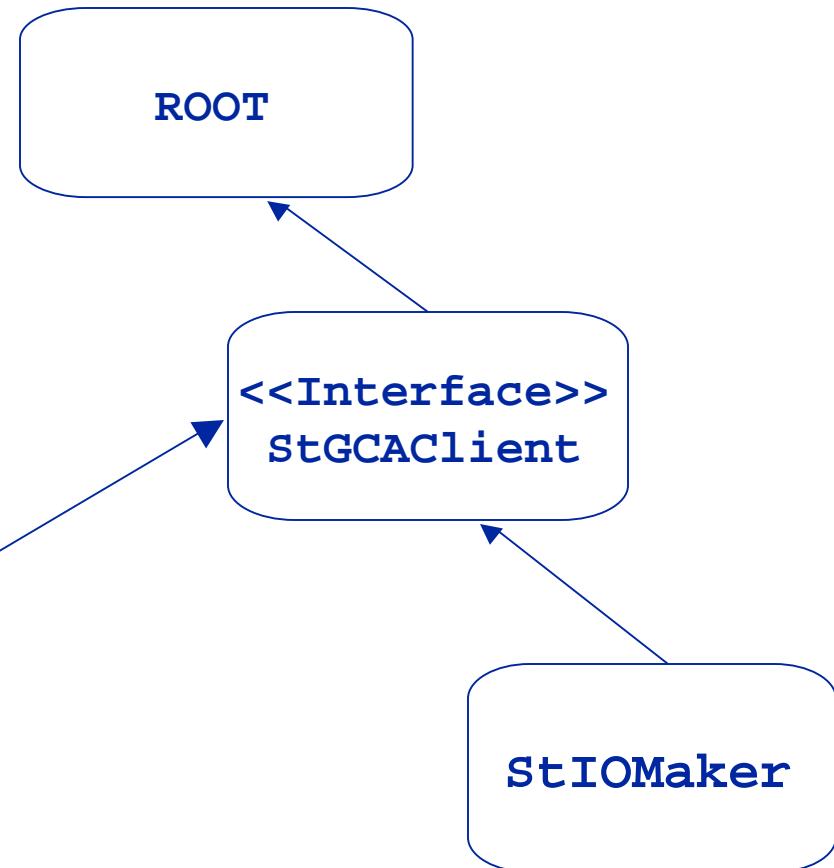
Eliminating Dependencies

CORBA + GCA software

/opt/star/lib



ROOT + STAR Software

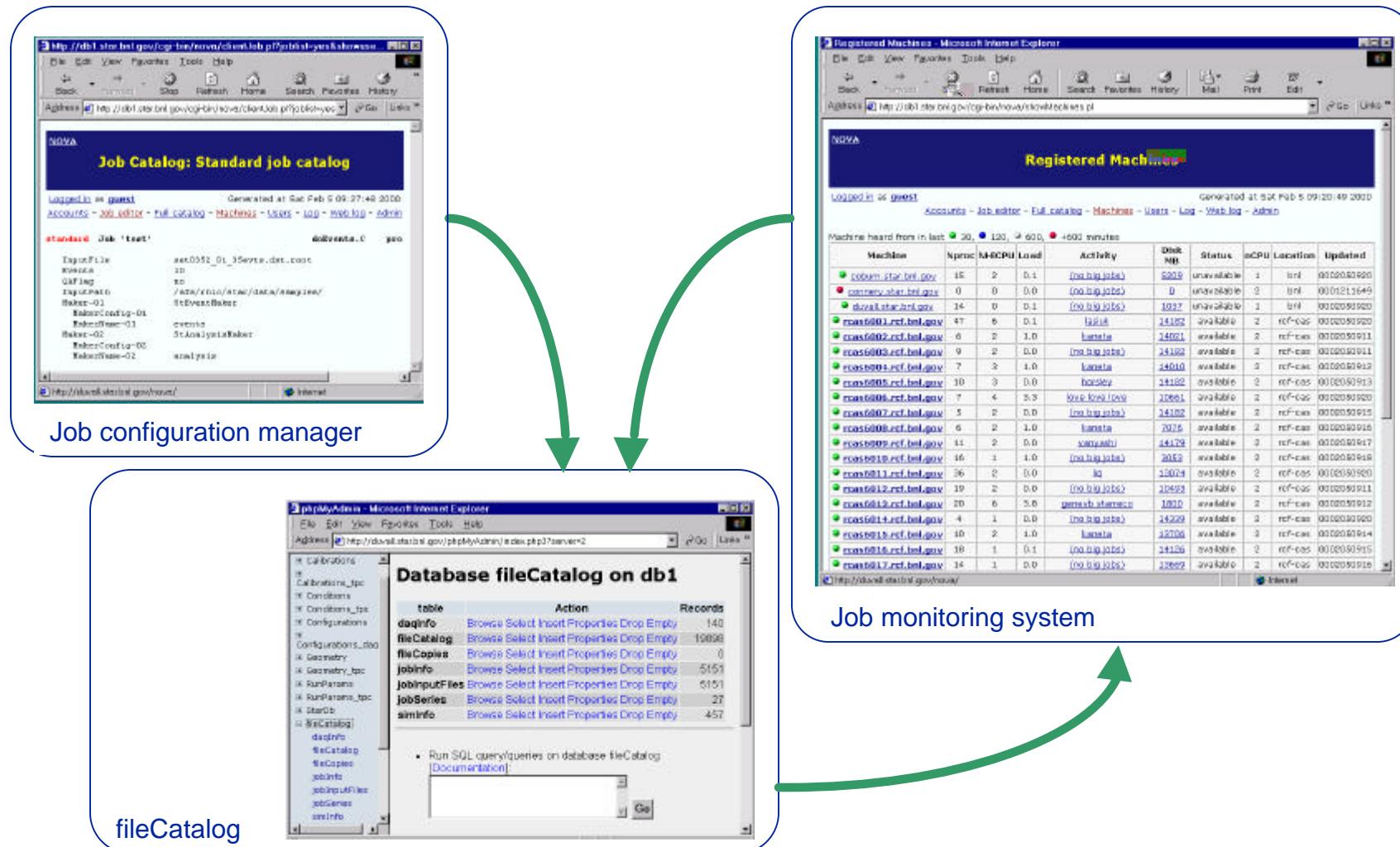




STAR *fileCatalog*

- Database of information for files in experiment.
File information is added to DB as files are created.
- Source of File information
 - for the experiment
 - for the GCA components (Index, gcaClient,...)

Cataloguing Analysis Workflow





GCA MDC3 Integration Work

<http://www-rnc.lbl.gov/GC/meetings/14mar00/default.htm>

Goals:

14-15 March 2000

status	goal	description / summary (as of 16Mar2000)
done	1 Build index on new STAR files	The index was build (several times) on the new STAR MDC3 data. This consisted of about 5,000 events. By the end of next week (start of MDC3) STAR expects about 140K events to put in the GC index. Sasha is continuing to accumulate additional event tag files as they are available.
done	2 Check that GCAClient and MinimalQuery work	Modifications to GCAClient and the MinimalQuery (& MinimalQuery1) test programs were completed for the updated version of STACS, including the new file bundle flag on the iterator.
done	3 Run MinimalQuery on linux	GCAClient & test program was compiled, run successfully on linux as well as Solaris. This included modifications to the Makefile to build both on linux & solaris.
done	4 Run multiple MinimalQuery simultaneously	Run on linux. Not verified yet on solaris.
done	5 Test index update	The feature of being able to update (add new events) to an existing index was justed added. This feature was first tested during this period. A number of bug fixes were made and the basic procedure is working. John is continuing to investigate one or two bugs before the procedure is declared reliable.
done	6 Test index update while queries are running	This is a functionality test and was successful. Any remaining work on the update functionality is not related to interlocks with running queries.
done	6.1 update between queries	This check is to run a query before the update and then after and verify that the results are accurate. This was successful.
done	6.2 update while new queries are being submitted	This tests the interlock mechanism so that queries do not run during the update process. This was successful.
in progress	7 Integrate GCAClient into root4star	This is the final work to connect the GCA to STAR data analysis. There were various discussions among Victor, Sasha, Jeff, Frank, Dave, Doug. The basic idea of how to incorporate the GCAClient into StlOMaker has been worked out by Victor, Sasha & Jeff. Sasha & Victor will work on it.



Status Today

- **MDC3 Index**
 - **6 event components:** •fzd
•geant
•dst
•tags
•runco
•hist
 - **179 physics tags:** •StrangeTag
•FlowTag
•ScaTag
 - **120K events**
 - **8K files**
- **Updated daily...**



User Query

ROOT Session:

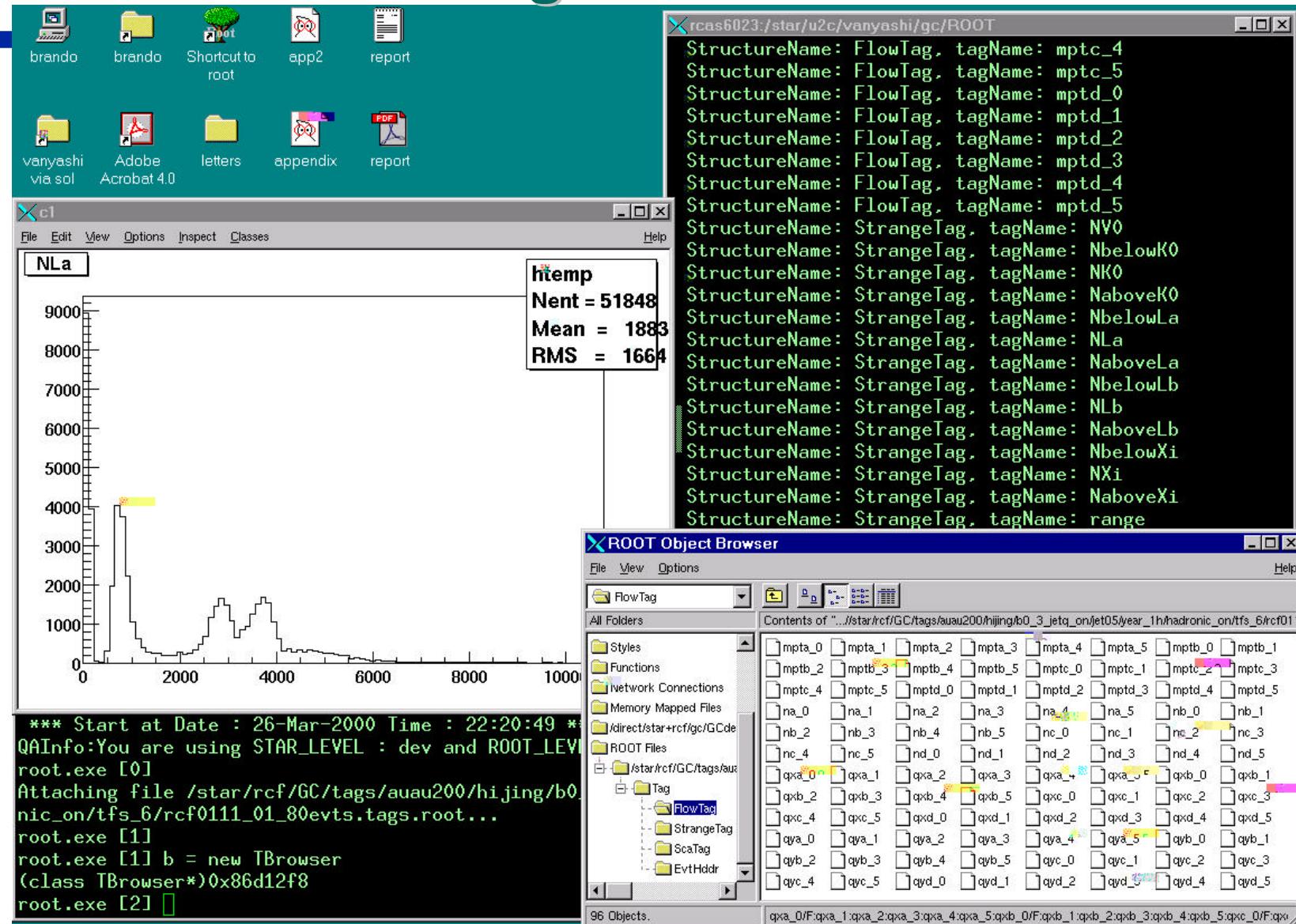
```
Xrcas6023:/star/u2c/vanyashi/gc/StGCAClient
1 mBeamPolarizationWest_0
1 mBeamPolarizationWest_1
1 mBeamPolarizationWest_2
1 mBImpact
1 mPhImpact
0 mGenType
0 mBunchCrossingNumber
0 mEventNumber
0 mEventTime
0 mEventDate
0 mProdTime
0 mProdDate
qM: 0x86cb588
qE: 0x86cb158
fC: 0x86cba40
qF: 0x86cbd48
a->Init()
*** OidSource is not set.

Submitting query: SELECT dst
                  WHERE -5<=qxa_3<0.3 && 22>qxc

qoF:: query created
qoF:: query added to list
query 0x86d0ce4
Full estimate is 205 events in 161 files ( unknown MBs).
```

```
Xrcas6023:/star/u2c/vanyashi/gc/StGCAClient
root.exe [0]
Processing test.C...
StGCAAdapter::LoadGCAServer: libStGCAClient.so loaded
StGCAAdapter::LoadGCAServer: new StGCAServer created.
StGCAServer::Init messages:
I will not attempt to follow refs returned via the iterator.
gcaResources: Attempting to read configFile /star/rcf/GC/MDC3/stacs.rc
Using configuration file "/star/rcf/GC/MDC3/stacs.rc".
Narrowing QE reference found in /star/rcf/GC/MDC3/logs/SM_QE.ref
Converting (string_to_object) IOR:0000000000000001549444c3a736d457374696c
00000005c00010000000000137273756e30302e7263662e626e6c2e676f76000006be00
2e676f763a5175657279457374696d61746f723a303a3a49523a736d457374696d61746f
Converted string_to_object
returning from findObjViaStringFile...
A Query Estimator has been contacted.
Converting (string_to_object) IOR:0000000000000001849444c3a716d4576656e74
00000005c00010000000000137273756e30302e7263662e626e6c2e676f76000006c100
2e676f763a51756572794d6f6e69746f723a313a3a49523a716d4576656e744974657261
Converted string_to_object
returning from findObjViaStringFile...
A Query Monitor is available to your OrderOptIterator.
Narrowing FileCatalog reference found in /star/rcf/gc/GCdev/FC/FileCatalog
Converting (string_to_object) IOR:0000000000000001449444c3a46696c65436174
400010000000000137273756e30302e7263662e626e676f760000883b000000000001
Converted string_to_object
returning from findObjViaStringFile...
A File Catalog has been found.
You are connected to a Query Factory.
Index Information
Name = simulated data for MDC3
Description =51749 events, 179 attributes, 6 components (all NULL FIDs a
00
number of components = 6
dst
fzd
geant
hist
runco
tags
0 tags
```

STAR Tag Database Access



The screenshot displays a desktop environment with several windows open:

- File Explorer:** Shows icons for brando, vanyashi via sol, Adobe Acrobat 4.0, letters, appendix, report, and a folder named "report".
- Terminal Window:**

```
*** Start at Date : 26-Mar-2000 Time : 22:20:49 *
QAInfo: You are using STAR_LEVEL : dev and ROOT_LEVEL : dev
root.exe [0]
Attaching file /star/rcf/GC/tags/auau200/hijing/b0_3_jetq_on/jet05/year_1h/hadronic_on/tfs_6/rcf0111_01_80evts.tags.root...
root.exe [1]
root.exe [1] b = new TBrowser
(class TBrowser*)0x86d12f8
root.exe [2]
```
- Plot Window:** A histogram titled "NLa" with axes from 0 to 10000. The plot shows two distinct peaks: one around 1000 and another broader one between 3000 and 4000. Text overlays provide particle identification information:

Htemp
Nent = 51848
Mean = 1883
RMS = 1664
- Text Window:** Displays a list of structures and tags from a database query:


```
rcas6023:/star/u2c/vanyashi/gc/ROOT
StructureName: FlowTag, tagName: mptc_4
StructureName: FlowTag, tagName: mptc_5
StructureName: FlowTag, tagName: mptd_0
StructureName: FlowTag, tagName: mptd_1
StructureName: FlowTag, tagName: mptd_2
StructureName: FlowTag, tagName: mptd_3
StructureName: FlowTag, tagName: mptd_4
StructureName: FlowTag, tagName: mptd_5
StructureName: StrangeTag, tagName: NVO
StructureName: StrangeTag, tagName: NbelowK0
StructureName: StrangeTag, tagName: NK0
StructureName: StrangeTag, tagName: NaboveK0
StructureName: StrangeTag, tagName: NbelowLa
StructureName: StrangeTag, tagName: NLa
StructureName: StrangeTag, tagName: NaboveLa
StructureName: StrangeTag, tagName: NbelowLb
StructureName: StrangeTag, tagName: NLb
StructureName: StrangeTag, tagName: NaboveLb
StructureName: StrangeTag, tagName: NbelowXi
StructureName: StrangeTag, tagName: NXi
StructureName: StrangeTag, tagName: NaboveXi
StructureName: StrangeTag, tagName: range
```
- Object Browser:** A window titled "ROOT Object Browser" showing the file structure of the attached root file:


```
File View Options
FlowTag
All Folders
Styles Functions Network Connections Memory Mapped Files
[root@star rcf/GC/tags/auau200/hijing/b0_3_jetq_on/jet05/year_1h/hadronic_on/tfs_6/rcf0111_01_80evts.tags.root]
  -> Tag
    -> FlowTag
    -> StrangeTag
    -> ScaTag
    -> EvtHeader
  -> qxa_0
  -> qxa_1
  -> qxa_2
  -> qxa_3
  -> qxa_4
  -> qxa_5
  -> qxb_0
  -> qxb_1
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Problem: SELECT NLa>700

3



STAR Tag Structure Definition

[./pams/global/idl/FlowTag.idl](#)

Version: [[.DEV](#)] [[DEV00](#)] [[SL00b_2](#)] [[SL99f](#)]

```
1 //  
2 // $Id: FlowTag.idl,v 1.3 2000/01/13 23:18:06 snelling Exp $  
3 //  
4 // Event by event flow tag  
5 //  
6 // $Log: FlowTag.idl,v $  
7 // Revision 1.3 2000/01/13 23:18:06 snelling  
8 // Changed sum pt to mean pt  
9 //  
10 // Revision 1.2 1999/11/16 20:59:40 snelling  
11 // Removed unused tags and added 6th harmonic  
12 //  
13 // Revision 1.1 1999/02/09 21:42:21 wenaus  
14 // Final (?) versions of MDC2 PWG tags  
15 //  
16 // The tags are defined for 4 subevents (a,b,c,d) and 6 harmonics  
17  
18 struct FlowTag {  
19     float qxa[6], qxb[6], qxc[6], qxd[6];      /* x component Q vector */  
20     float qya[6], qyb[6], qyc[6], qyd[6];      /* y component Q vector */  
21     long na[6], nb[6], nc[6], nd[6];           /* multiplicity */  
22     float mpta[6], mptb[6], mptc[6], mptd[6]; /* mean pt */  
23 };
```

Selections like
 $\sqrt{q_x^2 + q_y^2} > 0.5$
can not use index



Conclusion

- GCA developed a system for optimized access to multi-component event data files stored in HPSS.
- General CORBA interfaces are defined for interfacing with the experiment.
- A client component encapsulates interaction with the servers and provides an ODMG-style iterator.
- Has been tested up to 10M events, 7 event components, 250 concurrent queries.
- Is currently being integrated with the STAR experiment ROOT-based I/O analysis system.